International Journal of Humanities and Social Science Invention (IJHSSI)
ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714
www.ijhssi.org ||Volume 7 Issue 03 Ver. III ||March. 2018 || PP.51-58

On The Effects of Generative Learning Strategy on Students' Understanding and Performance in Geometry in Lafia Metropolis, Nasarawa State, Nigeria

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ABSTRACT: *This study adopted the quasi-experimental research design namely pretest and posttest, in examining the effects of generative learning strategy on the understanding and performance of secondary school students in geometry being one main branch of mathematics that is studied in Nigeria secondary schools. The purpose of the study was to explore new methods of assisting secondary school students in Nigeria to overcome the persistent high failure rate in general mathematics required for scientific and technological development otherwise the country would continue to trail behind in this respect. The sample for the study was made of 133 SSII students drawn from two public senior secondary schools in Lafia Metropolis, Nasarawa state, Nigeria. Purposive sampling technique was used in selecting the sample schools. Data was collected using GUPT consisting of 10 non-restricted multi-staged open-ended geometry questions with a reliability coefficient of 0.73. The findings from the study among other things revealed that statistically, the experimental group (Mean=28.82; SD=13.23) performed better with a significant mean difference in comparison with the control group (Mean=18.45; SD=7.51) in post-test (α=0.000<p-value=0.05); the difference in post-test mean scores between males (Mean=31.07; SD=12.82) and females (Mean=25.00; SD=13.27) in the experimental group was not statistically significant (α=0.999>p-value=0.05) meaning that the issue gender difference in mathematics performance is not significant when generative learning strategy is applied in teaching geometry to SSII students. Based on the findings from the study, some recommendations were made including the need for mathematics teachers to adopt generative learning strategy in teaching mathematics in the classroom; and that authors should endeavor to write textbooks for senior secondary schools to incorporate generative learning strategy in teaching mathematics.*

KEYWORDS -*Mathematics education, teaching, students, generative learning, strategy, geometry*

DATE OF SUBMISSION: 26-02-2018 DATE OF ACCEPTANCE: 13-03-2018

I. INTRODUCTION

The need for improved understanding and performance of secondary school students in mathematics in Nigeria in the present dispensation cannot be overemphasized. This is because the consensus of opinions have indicated that mathematics is very important in the scientific and technological development of any nation but Nigerian students have been scoring low marks below the standard expected in classroom tests and examinations, and their overall performance in general mathematics in the West African Senior Secondary Certificate Examinations (WASSCE) has not been impressive in recent years (Ayodele, 2001; Betiku, 2002; Binda, 2005; Federal Ministry of Education (FME), 2006; Bot, 2012; Ugwu, 2013). Beside these, the attitude of the students toward mathematics has not been positive and impressive as a result of numerous challenges including poor conceptual development (Kurumeh, 2006), gender difference, lack of parental support due to low profile education and poor socio-economic status (Obodo, 2001), the use of traditional teaching methods, inadequate quantity and quality of teachers, poor learning environment and lack of relevant and sufficient teaching and learning aids (Ukeje, 1999; Odili, 2006; Adeyemi, 2008).

The problem of poor performance in mathematics tend to affect female more than male students since numerous researches have revealed that the male students are better performers in many aspects in the secondary school mathematics curriculum including geometry, algebra and trigonometry (Shibley, Fennema & Lamon, 1990; Cox, 2000; Bot, 2012; Iji, Abakpa & Fekumo, 2013). Therefore, besides improving the understanding, performance and attitude of students toward mathematics, the issue of gender difference need to be mitigated holistically to enable all students learn mathematics equally to pave way for equal and active participation of all in nation building in Nigeria and the society at large.

Learning to understand mathematics properly means to comprehend and be able to apply it in solving practical problems. The process involves helping the students to clearly read, identify, express and represent problems themselves; and identify and recognize data in any given set of problems. Specifically, the process involves identifying a problem or set of problems with respect to given data; selecting the appropriate mathematical representations and procedures; computing the right solutions; interpreting the principles behind the solutions; and translating the ideas into a coherent form. This concurs with Bloom (1956) who submitted and maintained that individuals understand when they are able to recognize, recall, restate, translate and apply information. Clearly, it is through these and other processes that many struggling students tend to develop relevant cognitive and metacognitive learning skills and gain meaningful understanding of subject matter.

The ability to understand a subject matter is an important skill or competency that students need to learn and be able to apply mathematics through problem solving. For this reason, Grant (1978) and NCTM (2000) perceived understanding generally as being focal in instructional delivery. However, they urged that students should learn mathematics concepts and processes with full understanding less they grow and become unsuccessful problem solvers. To teach mathematics leading to meaningful understanding, requires a lot of work on the part of the teacher to assist students properly. These include their (students) consideration in terms of their intelligence, age, interest, maturity, socialization, temperaments, home or previous experience in the teaching and learning processes in order for the teacher to use the right type of approaches or principles. For example, having a good knowledge of students' levels of maturity and intelligence, a good teacher should be able to adopt the principles of moving from known to the unknown, concrete to abstract, simple to complex and specific to the general in preparing and teaching mathematics lessons in line with Piagets' theory for handling students with varying abilities and capabilities.

Also, the work of the teacher include consideration of the relevant materials for learning and planning instructions to cater for individual differences of students especially to stimulate and strengthen their enthusiasm and curiosity to learn; involving them actively in the learning process through questioning to clarify their difficulties and confusions; helping them to make their own discoveries of facts, ideas, principles and generalizations; establishing friendly relationships between teacher and students and within individual students to encourage cooperative learning; and above all, creating a good atmosphere for learning through the use of different approaches, other useful competences and exhibition of good and acceptable behaviours for effective, ideal and meaningful learning to take place. Once these elements are taking into consideration in the teaching and learning processes by the teacher, students will find mathematics interesting, easy to understand and apply.

However, to curb poor performance in mathematics among students in Nigeria, the use of novel strategies, concrete materials, revision exercises and mathematical games for arousing and sustaining their interest have been suggested by researchers (Gengle, 2013; Bot, 2012; WAEC Chief Examiner Report, 2009). Novel strategies in particular are needed to assist many weak students to learn mathematics in new and meaningful ways, understand and develop keen interest in it, use it to solve practical problems with success and achieve better results both in internal and external tests and examinations. This apart, it is necessary to bring in novelty and creativity in mathematics instruction thereby helping to inspire, stir up students to think, reason and solve problems independently.

One new teaching strategy that is useful but which has not been explored, employed and emphasized in mathematics instruction in Nigeria secondary schools due to traditional teaching or textbook-driven methods in use is generative learning. It has been conceived differently by researchers relative to their respective fields of study. For instance, Chiva, Grandio and Alegre (2010) defined it as the process of searching for (implicit) order, being a holistic understanding of anything or anyone that is interacted with (holo-organization). Vygotsky cited in Lewis, Pea and Rosen (2010) described it to mean something that forms the basis of human psychology and culture wherefore mediating signs people employ to understand and represent the experiential world, from language to signifiers are derived. In Senge's (1990) view, generative learning has to do with personal mastery, development of mental models, shared vision, team learning and systemic thinking.

In this context however, generative learning strategy is regarded as the process through which teachers engage their students actively in thinking, reasoning, conjecturing, understanding and applying mathematics through reading, copying, creating, constructing and solving problems. This concurs with Wittrock (1990) and Wittrock (1991) who stated and maintained that it is an approach that helps students to be active and responsible for constructing meaning from classroom activities and suggested thus: teachers need to inform students among other things that learning with understanding is a generative (active) process; success begins with a belief in their abilities, and in the value of their effort; and meaning is generated from what is learned. Therefore, it behooves on teachers to educate students accordingly especially by learning what models, preconceptions, strategies, attitudes and beliefs they (students) possess that are relevant to what they (teachers) need to teach in mathematics in the first place. Secondly, they (teachers) need to design instructions to enable students explore relations among subject-matter, models and knowledge. Thirdly, they (teachers) need to teach students cognitive and meta-cognitive strategies that are useful to direct their cognitive and affective thought processes. In essence, this suggests that before generative learning strategy is applied in mathematics instruction, the teacher and students must be ready for it.

Although a dearth of researches exist on the application of generative learning strategy, the little ones available have shown that the strategy is effective towards improving instructional practices and students' performance in many subjects including mathematics. For instance, Ritchie and Volkl (2010) found out that it assisted six-graders to achieve high and better scores with significant interaction effect in a science course. Van Blerkom, Van Blerkom and Bertsch (2006) discovered that 109 students that participated in reading/copying, reading/highlighting, reading/taking notes and generating questions, the latter group performed better than the first three groups.

In spite of the effectiveness of generative learning strategy, there is no research evidence showing that it is being utilized in mathematics instruction in the secondary school in Nigeria. Thus this study was conceived to fill this gab by examining its effectiveness on understanding and performance of students in geometry. Geometry is an important aspect of mathematics that is concerned with studying the nature and relations among shapes like triangles, squares and cubes. It is taught from primary to secondary schools in Nigeria to enable students understand natural phenomena, develop and promote thinking power and reasoning (Dangpe, 2008) but unfortunately it is a major component of mathematics that students record low marks (Chief Examiners' reports for WAEC, 2007, 2010; Lassa, 2012) from poor knowledge and lack of interest in mathematics (Ale & Adetula, 2010).

II. STATEMENT OF THE PROBLEM

The understanding cum performance of students in mathematics in the secondary school in Nigeria has been poor with their disposition to the subject negative as well. This problem, besides persisting, the rate seems to be increasing alarmingly as Ale and Adetula (2010), and Eniayeju and Azuka (2010) rightly posited and adhered, before Mathematics Improvement Project (MIP) was introduced in some selected schools in Nigeria, the performance rate was less than 40% in WASSCE examinations from 1999-2009 but after the introduction, the problem did not reduce significantly. Olosunde and Olaleye (2010) made similar remark stating that from 2001-2006, the failure rate has been on the increase nationally. This means something drastic must be done to reverse the ugly trend otherwise it may get worst and deter Nigeria from meaningful development.

The problem of poor performance of students in mathematics especially geometry in the secondary school in Nigeria is said to manifest in many amazing ways. These include inability of the students to (i) understand and explain concepts (ii) construct and label different shapes (iii) state and prove theorems (iv) translate and interpret word problems (v) represent problems by diagrams or symbols (vi) relate theorems to real life and (vii) avoiding or treating geometry questions carelessly (WAEC chief examiners' reports, 2008, 2009, 2010). These inabilities need to be curbed using new teaching strategies instead of old ones, less students will continue to perform poorly in geometry. Female students in particular will be affected most if the problem is not resolved since their performance is said to be low and below that of their male colleagues. The concern of this study in question form thus is: To what extent will the use of generative learning strategy help secondary school students learn, understand and improve their performance in geometry better than traditional teaching methods?

III. PURPOSE OF THE STUDY

The purpose of this study was to examine the effect of generative learning strategy on students' understanding and performance in geometry. Specifically, the study was designed to examine the levels of understanding, nature of performance and differential effect on gender after using generative learning strategy in teaching geometry among senior secondary school students.

IV. RESEARCH QUESTIONS

The research questions that guided the study are:

a. What is the level of understanding and performance of students in the experimental group?
b. What is the difference in mean scores between the experimental and control groups?
c. How do students differ in performance based on gender?

V. RESEARCH HYPOTHESES

The hypotheses for the study tested at 0.05 level of significance are:

a. The performance of the experimental and control groups will not differ significantly.
b. The performance of male and female students in the experimental group will not differ significantly.

VI. METHOD

The quasi-experimental research design was used in carrying out the study. The specific type was the pre-test and post-test non-equivalent control group in which sample for the study was taught based on their intact class arrangement. Sample comprised 133 Senior Secondary Two (SSII) students (75 males & 58 females) from two public senior secondary schools in Lafia Metropolis, Nasarawa state, Nigeria. The schools were selected using purposive sampling technique. School A comprised 62 students (39 males & 23 females) served as the experimental group coded EPG-A while school B comprised 71 students (36 males & 35 females) served as the control group coded CTG-B.

Data was collected using Geometry Understanding and Performance Test (GUPT). This consisted of ten major non-restricted open-ended questions seven of which were multi-staged with thirty subdivisions on geometry concepts of lines, angles, plane shapes; and construction of triangle, square, rhombus, rectangle and parallelogram. Performance based on the GUPT was classified into five levels thus: Poor Understanding (PU): 0-20marks; Low Understanding (LU): 21-30marks; Good Understanding (GU): 31-50marks; Impressive Understanding (IU): 51-70marks; and Excellent Understanding (EP): 71-100marks. The GUPT was scrutinized by experts for face and content validities; thereafter it was pilot-tested. The reliability coefficient of 0.73 was obtained using split-half reliability method.

Before the experiment, the sample was pretested using the GUPT. After the pre-test, the EPG-A received treatment, that is, learning of geometry concepts using generative learning strategy. This was done by a trained research assistant for four weeks using various concepts, materials and procedures to help motivate the students. These consisted of cut-out lines, angles, letters, figures, properties, diagrams, labels, questions, tables and illustrations. For example, the concepts were taught by lines and angles construction; explanation of terms and properties; examples; helping students apply concepts practically; asking students for explanations with feedback; and drawing inference. The students participated actively by questioning the teacher, themselves, peers; generating their own meanings; checking accuracy of their work; reading and identifying data; designing their own solutions; and presenting new information and so on. This enabled two-way interactive discussion (teacher/students, students/students or peers) that served to facilitate the teaching and learning processes.

The CTG-B on the other hand was taught similar concepts in geometry as the EPG-A with the use of a traditional expository teaching method. After the experiment, the EPG-A and CTG-B were post-tested using revised version of the GUPT. The data collected was analysed using descriptive and inferential statistics.

VII. RESULTS

Table 1. Performance Levels of the Experimental and Control Groups in Pretest

Group	UnderstandingLevel	MarksRange	BoysFreq.	%	GirlsFreq.	%	Total	%
Exp.	PU	0-20	39	62.90	23	37.10	62	100
	LU	21-30	-	-	-	-	-	-
	GU	31-50	-	-	-	-	-	-
	IU	51-70	-	-	-	-	-	-
	EU	71-100	-	-	-	-	-	-
Cont.	PU	0-20	36	50.70	35	49.30	71	100
	LU	21-30	-	-	-	-	-	-
	GU	31-50	-	-	-	-	-	-
	IU	51-70	-	-	-	-	-	-
	EU	71-100						

Key: Exp.=Experimental group, Cont.=Control group, Freq.=Frequency

In Table 1, the pretest results revealed that besides equivalent entry behaviors and performance levels, the experimental and control groups tend to have poor understanding of geometry since both groups scored low marks in the range of 0-20 (100%) PU.

Table 2. Performance Levels of the Experimental and Control Groups in Posttest

Group	UnderstandingLevel	MarksRange	BoysFreq.	%	GirlsFreq.	%	Total	%
Exp.	PU	0-20	8	12.90	9	14.52	17	27.42
	LU	21-30	12	19.35	7	11.29	19	30.65
	GU	31-50	16	25.81	6	09.68	22	35.48
	IU	51-70	3	04.84	1	01.61	4	06.45
	EU	71-100	-	-	-	-	-	-
Cont.	PU	0-20	24	33.80	23	32.39	47	66.20
	LU	21-30	11	15.49	9	12.68	20	28.17
	GU	31-50	1	01.41	3	04.23	4	5.63
	IU	51-70	-	-	-	-	-	-
	EU	71-100	-	-	-	-	-	-

Key: Exp.=Experimental group, Cont.=Control group, Freq.=Frequency

In Table 2, the posttest results revealed that the experimental group performed better than the control group. For instance, only 17 students (27.42%) from the experimental group scored 0-20marks PU while 47 students (66.20%) from the control group scored 0-20marks PU. Also, whereas 4 students (6.45%) scored between 51-70marks IU from the experimental group, no single student from the control group scored marks in this range.

Table 3.T-test Statistics Computationof Significance of Mean Score Difference between the Experimental and Control Groups in Pretest and Posttest

Test	Group	N	Mean	SD	t-cal.	df	Sig.	P	Decision
Pretest	Experimental	62	1.92	2.52	0.186	131	0.649	0.05	Accepted
	Control	71	1.84	2.08					
Posttest	Experimental	62	28.82	13.23	5.65	131	0.000	0.05	Rejected
	Control	71	18.45	7.51					

Table 3 revealed that statistically (i) there is no significant difference in mean scores between the experimental (Mean=1.92; SD=2.52) and control groups (Mean=1.84; SD=2.08) in pretest (α=0.649>p-value=0.05) (ii) the difference in mean scores between the control (Mean=18.45; SD=7.51) and experimental groups (Mean=28.82; SD=13.23) is significant in favor of the latter group in posttest (α=0.000<p-value=0.05).

Table 4.T-test Statistics Computationof Significance of Mean Score Difference between the Experimental and Control Groups in Posttest Based on Gender

Group	Sex	N	Mean	SD	t-cal.	df	Sig.	P	Decision
Experimental	Males	39	31.07	12.82	5.451	73	0.000	0.05	Rejected
Control	Males	36	17.92	7.00					
Experimental	Females	23	25.00	13.27	2.145	56	0.007	0.05	Rejected
Control	Females	35	19.00	8.05					
Experimental	Males	39	31.07	12.82	1.779	60	0.999	0.05	Accepted
Experimental	Females	23	25.00	13.27					

From the posttest results in Table 4, statistically (i) the difference in mean scores between males in the experimental (Mean=31.07; SD=12.82) and control groups (Mean=17.92; SD=7.00) is significant favoring the experimental group (α=0.000<p-value=0.05) (ii) the difference in mean scores between females in the experimental group (Mean=25.00; SD=13.27) and those in the control group (Mean=19.00; SD=8.05) is significant still in favor of the experimental group (α=0.007<p-value=0.05) and (iii) the difference in mean scores between males (Mean=31.07; SD=12.82) and females (Mean=25.00; SD=13.27) in the experimental group is insignificant (α=0.999>p-value=0.05).

Table 5. ANOVA Between and Within the Experimental and Control Groups

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3560.517	1	3560.517	31.941	0.000
Within Groups	14602.626	131	111.470		
Total	18163.143	132			

The summary of results in Table 5 revealed that $F_{(1,131)}$=31.941, α=0.000<p=0.05 implying that the variation between the experimental and control groups is statistically significant. In order words, the treatment had a significant effect and variation on performance of students in the experimental group after controlling for the effect of traditional teaching method.

Table 6. ANCOVA Computation of Significance of the Treatment Condition

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6890.449[a]	2	3445.224	39.731	0.000
Intercept	30079.257	1	30079.257	346.883	0.000
Method	3329.932	1	3329.932	38.402	0.000
Grouping	3448.760	1	3448.760	39.772	0.000
Error	11272.694	130	86.713		
Total	90279.000	133			
Corrected Total	18163.143	132			

a. R Squared = 0.379 (Adjusted R Squared = 0.370)

From Table 6, the main treatment effect is significant since $F_{(1, 130)}$=39.772, α=0.000<p=0.05, that is, the treatment assisted the students to perform significantly better than those who did not receive it after controlling pretest effect.

Table 6. ANCOVA Computation of Contrast between the Experimental and Control Groups

Grouping Simple Contrast[a]		Dependent Variable: Strategies
Group 1 vs. Group 2	Contrast Estimate	-10.209
	Hypothesized Value	0

	Difference (Estimate-Hypothesized		-10.209
	Std. Error		1.619
	Sig.		0.000
	95% Confidence Interval for Difference	Lower Bound	-13.412
		Upper Bound	-7.006

a. Reference category = 2

From Table 6, the contrast estimate (-10.209) between the groups (α=0.000<p=0.05) means the treatment had a significant differential effect on students' performance, that is, it increased the performance of the experimental group significantly.

VIII. DISCUSSION

It is a truism to say that in Nigeria and elsewhere worldwide, without mathematics, no substantial and meaningful development can take place since the knowledge is indispensable in the advancement of science and technology being the major determinants of modern society. Thus it behooves on Nigeria to keep searching for new and relevant methods and strategies that would assist in mitigating the problem of poor understanding and performance of students in mathematics required for the purpose of national development. This is premised on the fact that once the new methods and strategies are utilized, students will not only understand what they are taught better but it will also help develop their interest and hence improve their overall performance in mathematics. Thus this study examined the effectiveness of generative learning as a new teaching strategy on the understanding and performance of students in geometry since geometry is one of the major areas of mathematics that is perceived to be difficult and without teaching it well, it would be difficult to have students in the secondary school learn mathematics successfully.

Consequently, the findings from this study (Table 1) revealed that secondary school students indeed have the problem of poor understanding and performance in geometry based on their pretest scores ranging from 0-20marks, that is, 100% PU. This implies that, besides having equivalent entry behaviors, the students lacked good foundation knowledge of geometry. This agrees with many observations (Chief Examiners' reports for WAEC, 2007, 2010; Lassa, 2012) and researches (Ale & Adetula, 2010; Eniayeju & Azuka, 2010; Olosunde & Olaleye, 2010) that students have poor mathematics background knowledge. However, the posttest results (Table 2) revealed that the students performed better in the experimental than the control group. For instance, whereas the experimental group demonstrated GU with 22 students (35.48%), only 4 students (5.63%) did that in the control group meaning that the treatment assisted more than anything.

Table 3 revealed that the mean score difference in performance of the experimental and control groups is statistically significant (α=0.000 < p-value=0.05) in favor of the experimental group (Mean=28.82; SD=13.23) against the control group (Mean=18.45; SD=7.51). This means the treatment assisted the experimental group in their understanding and performance in geometry significantly better than the control group. This concurs with Van Blerkom, Van Blerkom and Bertsch (2006) who found out that generative learning strategy involving reading, responding, copying, highlighting, notes and questioning helped students to perform significantly better than those not exposed to it. Also, the findings concur with Bot (2012), Bot and Emefo (2014) and Eze and Bot (2014) who found out that mathematical modelling, concept mapping and cooperative learning respectively resulted in significant effect on students' achievement mean scores in mathematics against using traditional teaching methods and strategies.

Based on gender, the findings of this study (Table 4) revealed no statistical significant mean difference between performance of male (Mean=31.07; SD=12.82) and female students (Mean=25.00; SD=13.27; α=0.999>p-value=0.05) in the experimental group. This means the use of generative learning strategy is effective in assisting students to improve their performance in geometry irrespective of whether they are boys or girls. This agrees with Bot (2012), Cox (2000), Ezeugo and Agwagah (2000) and Slavin (1987) but it is in contrast with the findings of Eniayeju (2010) who discovered that though cooperative learning, being a new strategy, led to significant mean differential effect on the performance of students in mathematics based on gender, girls performed significantly better than boys.

Similarly, the findings of this study contradict the findings of Bot (2013) who discovered that although mathematical modelling led to significant mean difference in achievement scores of students in mathematics, there is no significant mean difference between that of boys and girls in the experimental group. This means the controversy of gender affecting mathematics achievement is inconclusive thereby contradicting Cox (2000) who maintained that generally, studies on gender differences show that males are superior to female students.

IX. RECOMMENDATIONS

Based on the findings of this study, therefore, the following recommendations are made:

- Teachers should employ generative learning strategy. This will help students not only to learn geometry with understanding but also to improve their overall performance.

- Generative learning is an effective innovative teaching and learning strategy. Its use, besides improving understanding and performance, it will bring novelty in mathematics instruction with high tendency to assist students develop interest in learning geometry. Therefore, teachers need to take advantage of the strategy to improve the lot of students in mathematics.
- Teachers should adopt generative learning strategy to reduce the rate which they rely solely on traditional methods which hardly result in effective teaching and impressive performance for students in mathematics.
- Curriculum planners should incorporate generative learning in curriculum guidelines for mathematics instruction in the secondary school to help facilitate the achievement of intended learning goals in mathematics especially in geometry.
- The mathematics textbook is one of the most important tools for effective mathematics instruction in the secondary school in Nigeria and elsewhere worldwide. Consequently, authors are encouraged to write textbooks that contain different approaches including generative learning. This will help provide variety in pedagogy and update the books.
- Further research should be done on the relative effectiveness of generative learning in teaching and learning algebra, introductory calculus and logic in the secondary school in Nigeria. Aside these topics, the relative effectiveness of the strategy should also be examined on motivating and sustaining students' interest in mathematics based on gender, ability and school type.

X. CONCLUSION

In this study, it has been demonstrated that generative learning strategy is effective in improving understanding and performance of students in geometry. Since the search for new strategies, techniques or methods that will help students overcome their challenges in learning mathematics is an on-going process in Nigeria and beyond, teachers should begin to explore generative learning strategy in mathematics instruction because of the potentialof guaranteeing successful teaching and learning. They cannot afford to wait for too long in the present circumstance.

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Thomas D. Bot (Ph.D)."On The Effects of Generative Learning Strategy on Students' Understanding and Performance in Geometry in Lafia Metropolis, Nasarawa State, Nigeria." International Journal of Humanities and Social Science Invention (IJHSSI) 7.03 (2018): 51-58.